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Single Channel Ultrasonic Inspection System (ULTIMA 200S)

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Abstract

ULTIMA 200S is a single channel Ultrasonic Testing System suitable for inspection of materials. It is based around an Industrial Personal Computer (IPC), which serves as the central controller. The electronics hardware constituents viz. Pulser/Receiver, Amplifier, Digitizer and Rectifier are configured in the form of a dedicated set of ISA and PCI bus compatible PC add on boards. It can also be interfaced to the external Pulser/Receiver units. A comprehensive windows based menu driven software package has been developed under CVI (LAB WINDOWS) for implementation of data acquisition, storage, signal analysis / processing and information display. The Digitizer card is the key element of this system. It can sample the ultrasonic echo signals at a maximum sampling rate of 200 Mega Samples Per Second (MSPS) and features a PCI bus interface supporting a peak data transfer of 50 Mbytes/sec. to/fro the host. This enables very fast update of A-Scan on the screen. A special feature of the system is simultaneous display of the acquired data and its amplitude spectrum (FFT) in near real time. The software enables the operator to select appropriate parameters for acquiring optimum data and presenting the information in a desired manner. A status window is always available on the screen, to indicate the values of parameters selected by the user. Thus the key information regarding data acquisition is always available to the user. Two gates have been provided which generate an alarm whenever the acquired data crosses the amplitude limits set within the gates.

1. Introduction

Ultrasonic Imaging techniques play a vital role in Non-Destructive Testing/Evaluation of critical mechanical parts. Such techniques are very useful in quality assurance/control, material characterization and can be employed during the pre service, in-service and post service stages of inspection of metallic components. ULTIMA 200S is suitable for such inspection / testing operations. This system is an upgraded version of ULTIMA 100+ [(1)] , developed earlier at Electronics Division, BARC. The major hardware change is the incorporation of PCI bus based digitizer card, capable of sampling data at 200 MSPS. A new software package has been developed for system control, data acquisition and information display. This Windows98 based software has been developed under Lab-Windows (CVI) platform. A new feature consists of the provision for display of the A-Scan waveform along with the amplitude spectrum of a desired portion of the same. User definable “gates” have been provided for monitoring the status of the portion of the signal lying within the gate. Routines for generation and display of B-scan images have been developed and routines for C-scans are under development.
This paper aims to highlight the features of ULTIMA 200S.

2. ULTIMA 200S SYSTEM DESCRIPTION

2.1 Hardware

ULTIMA 200S is a single channel ultrasonic inspection system based around an industrial personal computer. Industrial PC has been chosen because it provides a mechanically robust and environmentally rugged platform. Usage of passive back plane with large number of expansion slots provides ease of upgradation and thus offers flexibility to the system.

Electronics hardware of ULTIMA 200S consists of pulser receiver, amplifier[(l)], and digitizer cards. An integrated menu driven software package has been developed under Lab Windows to enable the user to acquire, display & process the data. Block diagram of the system is shown in Fig.1

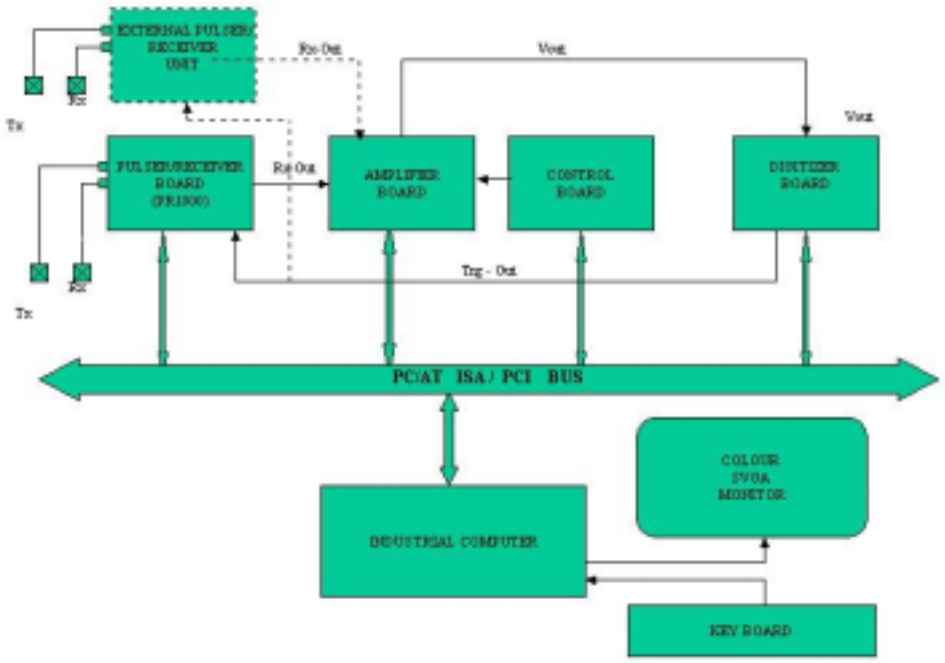

Figure 1
BOLCK DIAGRAM FOR SINGLE CHANNEL ULTRASONIC INSPECTION SYSTEM ULTIMA 200S

The main functional block of the system are :

1. The pulser receiver
2. Broadband Amplifier
3. 200 MSPS digitizer

Each block has been designed as function specific PC add-on card. This permits one to change a board of specific functionality without making any major change in the overall system configuration.

2.1.1 Pulser Receiver :

The Pulser section generates the high voltage transmit pulse needed for the excitation of the ultrasonic transducer and the receiver amplifies the received echo signals. A high voltage MOSFET is employed for generating a voltage spike of approx. 300V amplitude, which energizes the transducer. The sharp rise time (< 20nsec) and narrow width (around 100nsec) of the transmit pulse allows the use of pulse mode transducers over a frequency range of 1-20MHz.

Following modes of operation are supported:

i) Pulse-Echo (PE) mode

ii) Transmit-Receive (T/R) mode

Some of the user selectable parameters of the pulser are :

* Pulser Enable : On/Off
* Transmit Pulse Amplitude : 150 V/ 300V
* Damping Control : 500/250/100/50 ohms

The RF echo signals sensed by the receiving transducer are routed to the receiver section for amplification. The receiver features a 3dB bandwidth of 40 MHz and 0-40 dB gain, adjustable in steps of 0.25 dB. User selectable bandwidth limiting filters are also provided for optimizing signal to noise ratio (SNR). The processed signal is fed to the main amplifier for further amplification.

Provision is made for interfacing an external pulser /receiver unit or an Ultrasonic flaw detector provided they operate with external trigger signal. In such a case the digitizer provides the trigger for the external pulser/ Flaw Detector and the corresponding analog (RF/ envelope detected) output can be routed through the amplifier board if additional gain is necessary. Flaw detectors providing a " trigger out " signal can also be interfaced with ULTIMA 200S.

2.1.2 Amplifier

The amplifier board provides an additional gain of 40 dB with a 3dB bandwidth of 40 MHz. The gain can be set in steps of 0.25 dB giving the operator adequate flexibility for data collection. The amplified signal is buffered and routed to the Digitizer board for digitization and storage.

2.1.3 Digitizer

The digitizer is a PCI bus based PC add-on board [2,3] capable of sampling ultrasonic echo signals (i.e. A-Scan waveforms) at a maximum sampling rate of 200 MSPS. It features an extremely fast data throughput rate (50 Mbytes/Sec) typical to the host PC. This in turn enables very fast updates of A-Scan screen. The sampling rate is software selectable from 0.781 KSPS to 200 MSPS.. The digitizer also provides trigger signal to the Pulser receiver card as per the selected Pulse repetition frequency (PRF) ranging from 100Hz to 6KHz. A provision of programmable initial delay has been made to start acquisition at the desired location if required so. For immersion scanning mode first echo detection circuit, which initiates the acquisition on receiving the first echo (from top surface of the specimen) has also been incorporated. Provision of a 'variable record length' enables the user to trade off between the PRF and the depth range.

2.2 Software

A powerful, Windows98 based 'Control, Display & Signal Processing/Analysis' software has been developed. This software package enables the operator to select appropriate parameters for acquiring optimum data and presenting the information in a meaningful way. While storing A/B scans, all the associated parameters (such as sampling rate, pulser receiver settings, Amplifier gain etc.) along with the digitized A-Scan data also get stored. This is extremely useful for future referencing. Provision has been made to display the A-scan data & amplitude spectrum (FFT) of a selected portion (of the A-Scan) simultaneously. Thus echo signals can thus be analyzed in frequency domain in near real time.

A status window indicating the major parameters selected by the users is always available on the screen. Another new useful feature of the system is the provision of two independent user selectable "gates". User can define and locate each gate at the desired portion of the A-Scan and also specify the desired amplitude threshold. If this threshold is crossed within the gate interval an audible beep is generated.

3. Results And Discussions

ULTIMA 200S has been used to inspect a variety of specimens at U.I.S. / ED and the system performance is found to be quite satisfactory. Detailed evaluation is being planned.

Figure 2 shows a sample A-Scan waveform along with the amplitude spectrum of the selected echo.

Figure 3 shows a B-Scan image of an aluminum sample having different steps.

4. Acknowledgements

Authors wish to thank Shri T.S.A.Krishnan for his valuable suggestions for development of software under LabWindows (CVI) platform. Authors gratefully acknowledge the efforts and contributions made by Smt. P.Jyothi and Ms Shobha Chavan in the assembly and testing of the PCB's.

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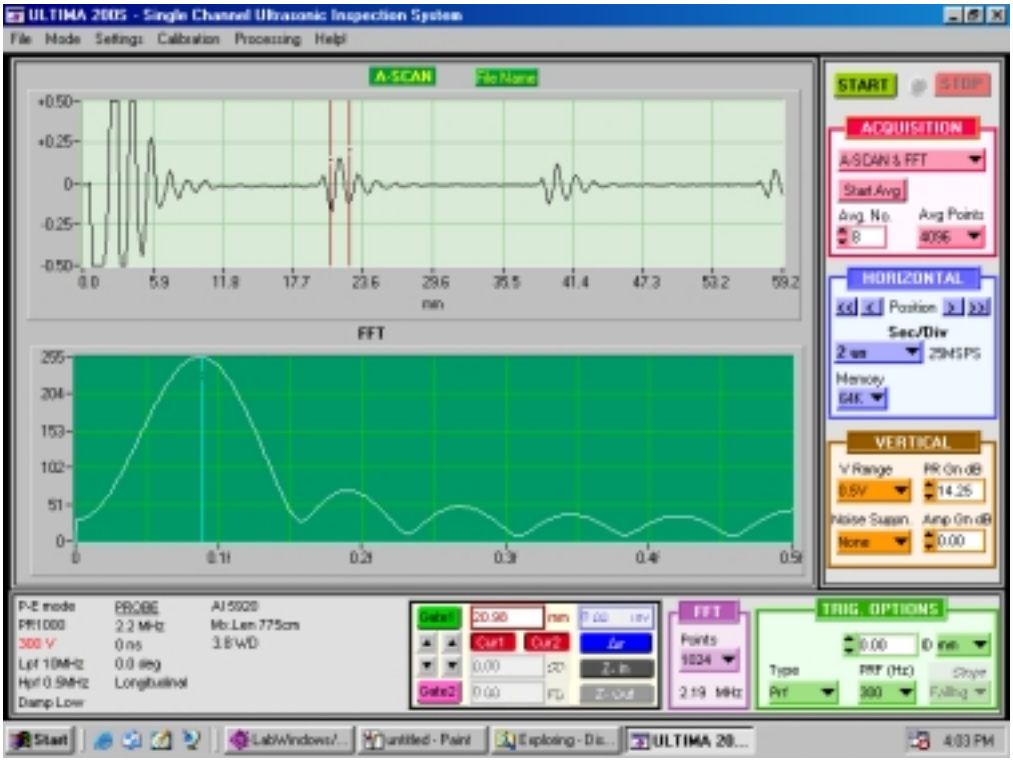

Figure 2. A typical A-Scan waveform alongwith amplitude spectrum of the gated echo.

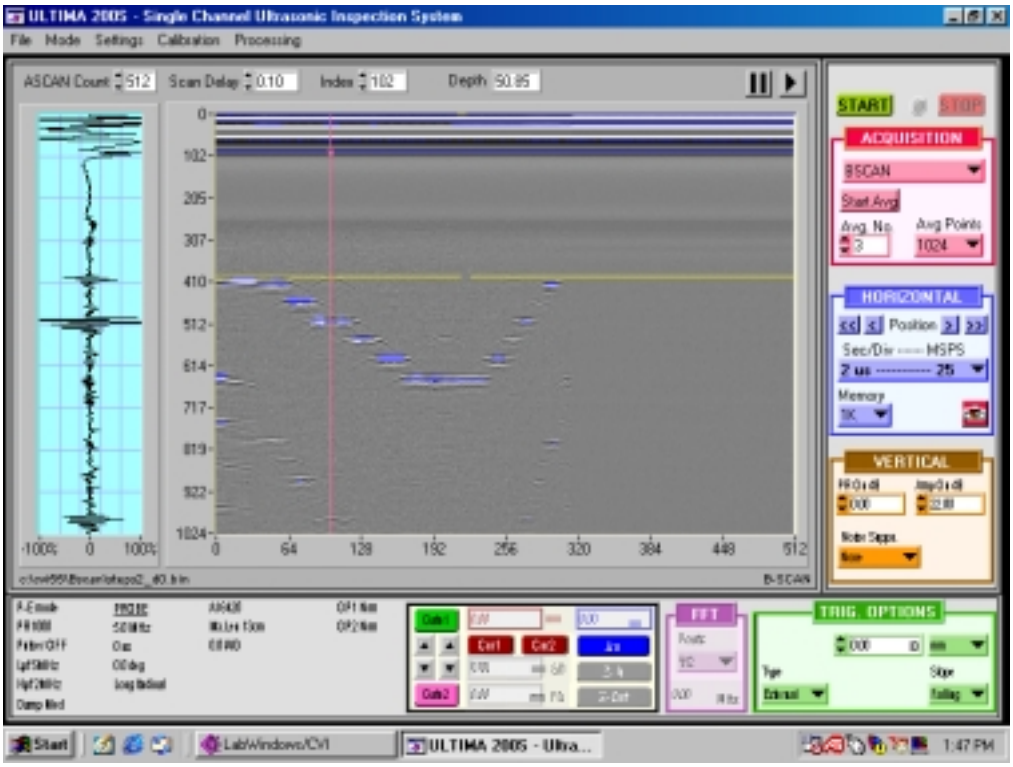

Figure 3: A sample B-Scan of an aluminum test block having steps of different widths